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Yeom et al.

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(54) **TSTD TRANSMITTER FOR LIMITING TRANSMISSION POWER OF ANTENNA AND CONTROLLING METHOD THEREOF FOR BASE STATION IN MOBILE COMMUNICATION SYSTEM**

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(51) **Int. Cl.**[7] **H04J 3/00**

(52) **U.S. Cl.** **370/345**; 370/342; 455/101; 375/267; 343/876

(58) **Field of Search** 370/342, 320, 370/335, 318, 345; 455/522, 101; 375/267, 299, 347, 146; 343/876

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,787,122 A * 7/1998 Suzuki 375/299

OTHER PUBLICATIONS

"Transmission Diversity in Wideband CDMA", Ratiola, M., Hottinen, A., Wichman, R, Vehicular Technology Conference, 1999 IEEE 49[th], vol. 2, 1999, pp. 1545–1549.*

* cited by examiner

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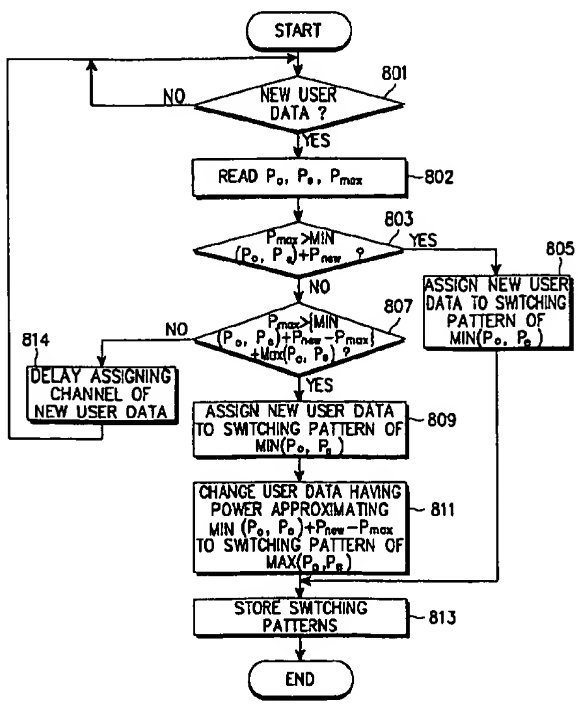
(57) **ABSTRACT**

A device and method are provided for limiting a power of a signal transmitted through any antenna to a maximum transmission power of the antenna in a TSTD (Time-Switched Transmission Diversity) transmitter of a base station of a mobile communication system. In a TSTD transmitter including at least two antennas and a pattern storage for storing a maximum transmission power limit value and switching patterns of a plurality of user data to be transmitted through the antennas, transmission powers assigned to antennas are measured upon receipt of new user data. A switching pattern is determined such that a value obtained by adding one of the transmission powers to a transmission power of the new user data does not exceed the maximum transmission power limit value.

9 Claims, 8 Drawing Sheets



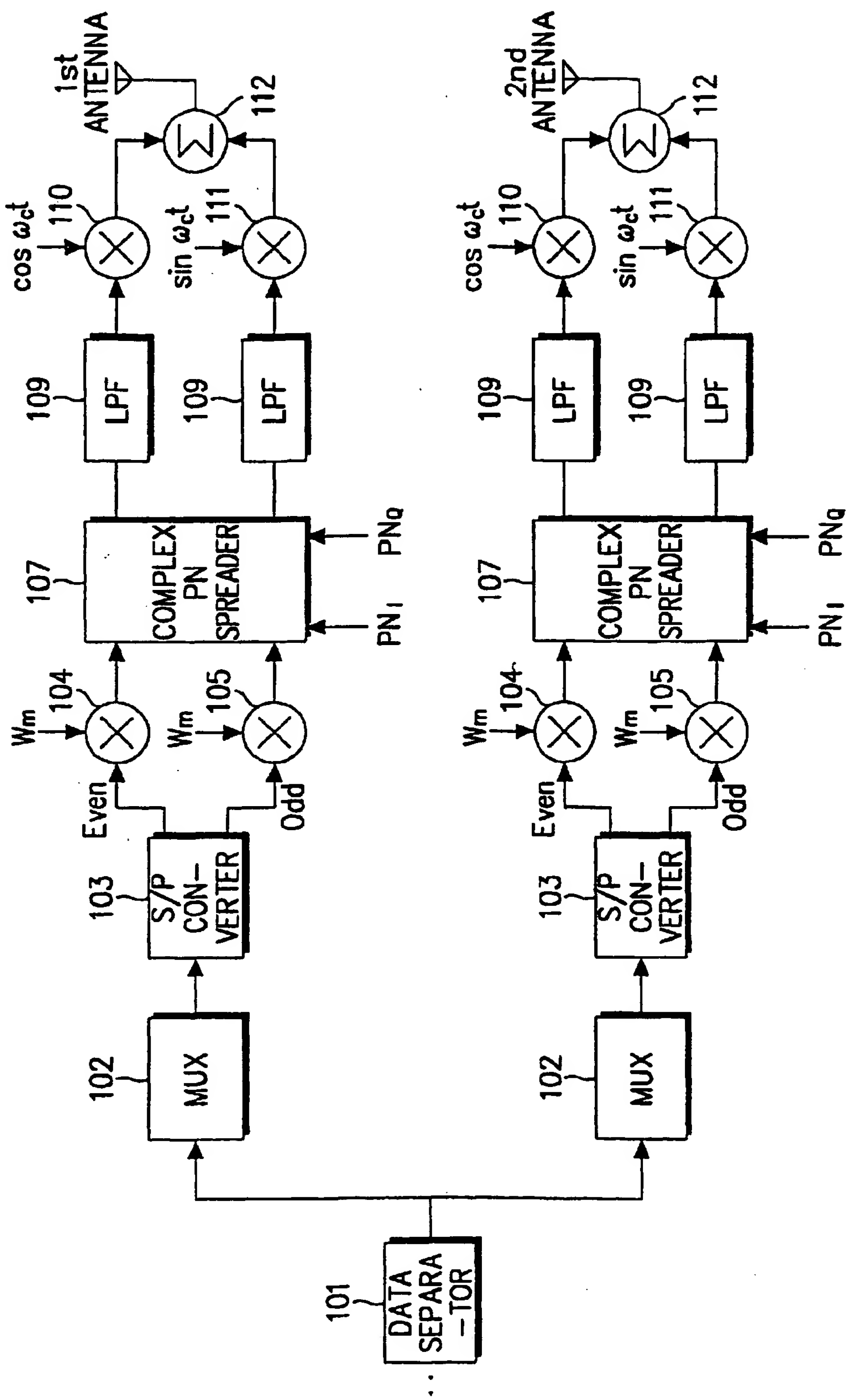


FIG. 1 (PRIOR ART)

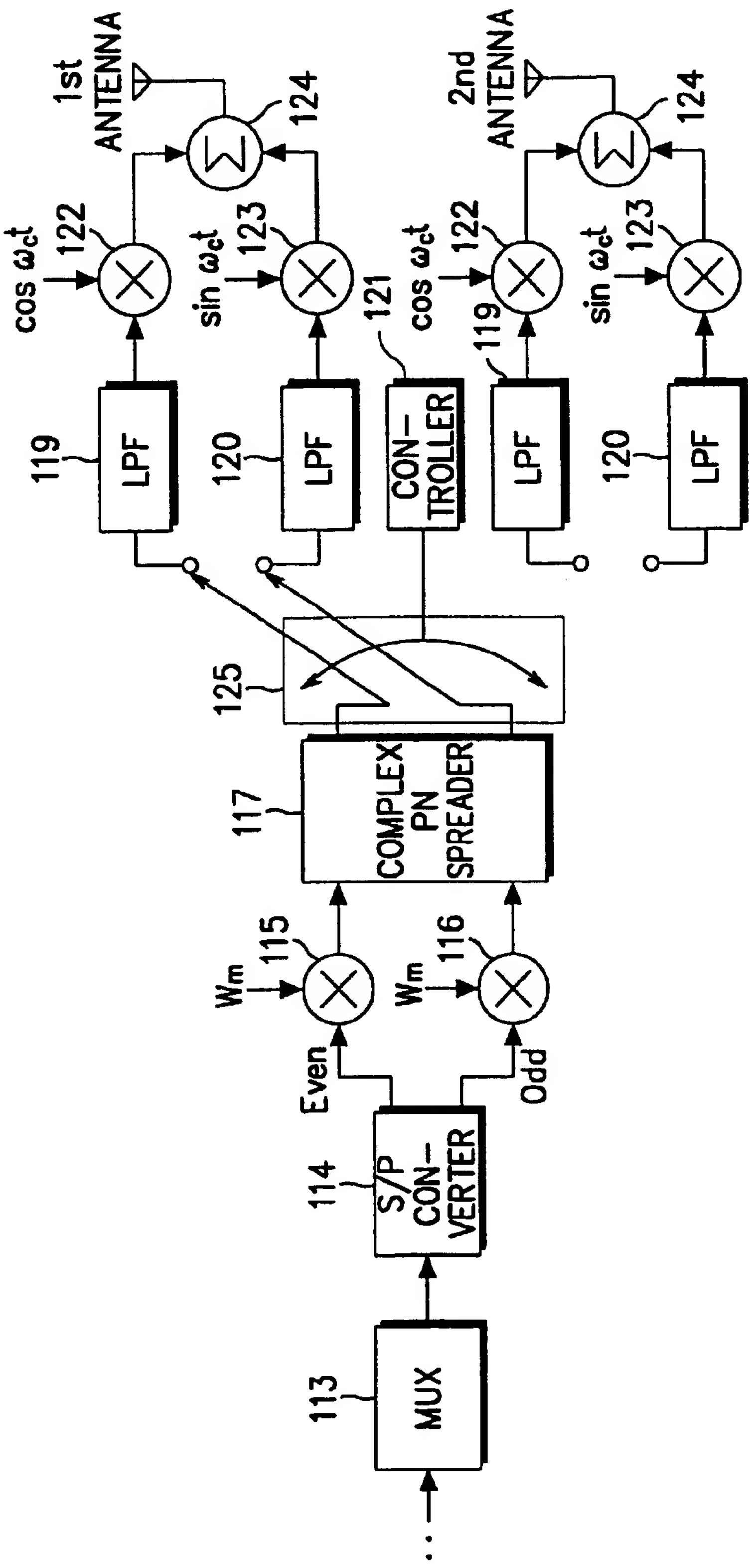


FIG. 2
(PRIOR ART)

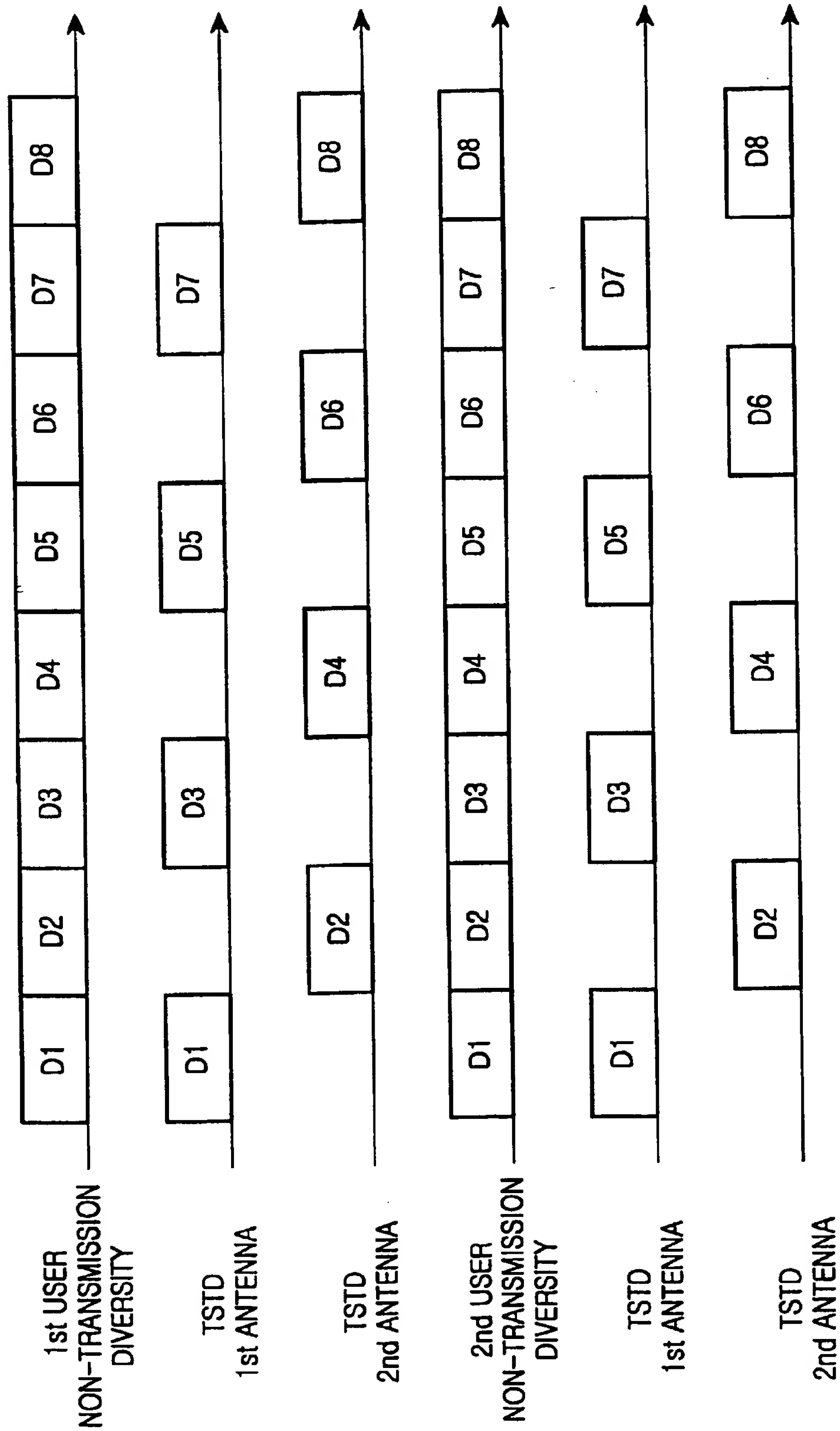


FIG.3
(PRIOR ART)

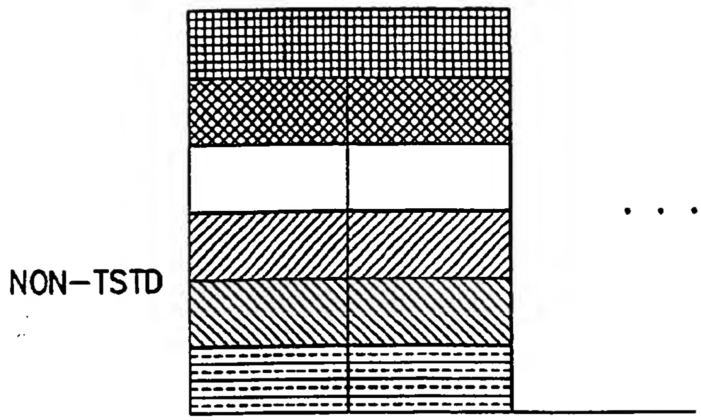


FIG. 4A
(PRIOR ART)

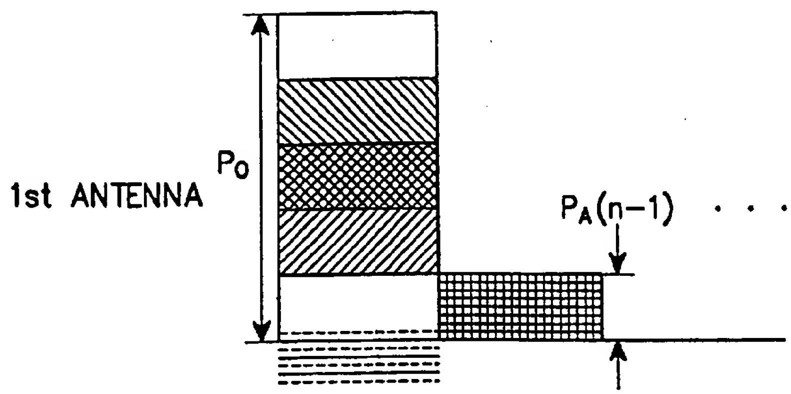


FIG. 4B
(PRIOR ART)

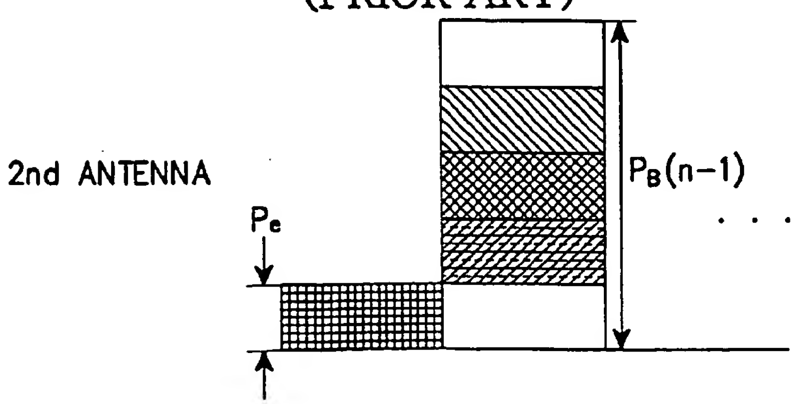


FIG. 4C (PRIOR ART)

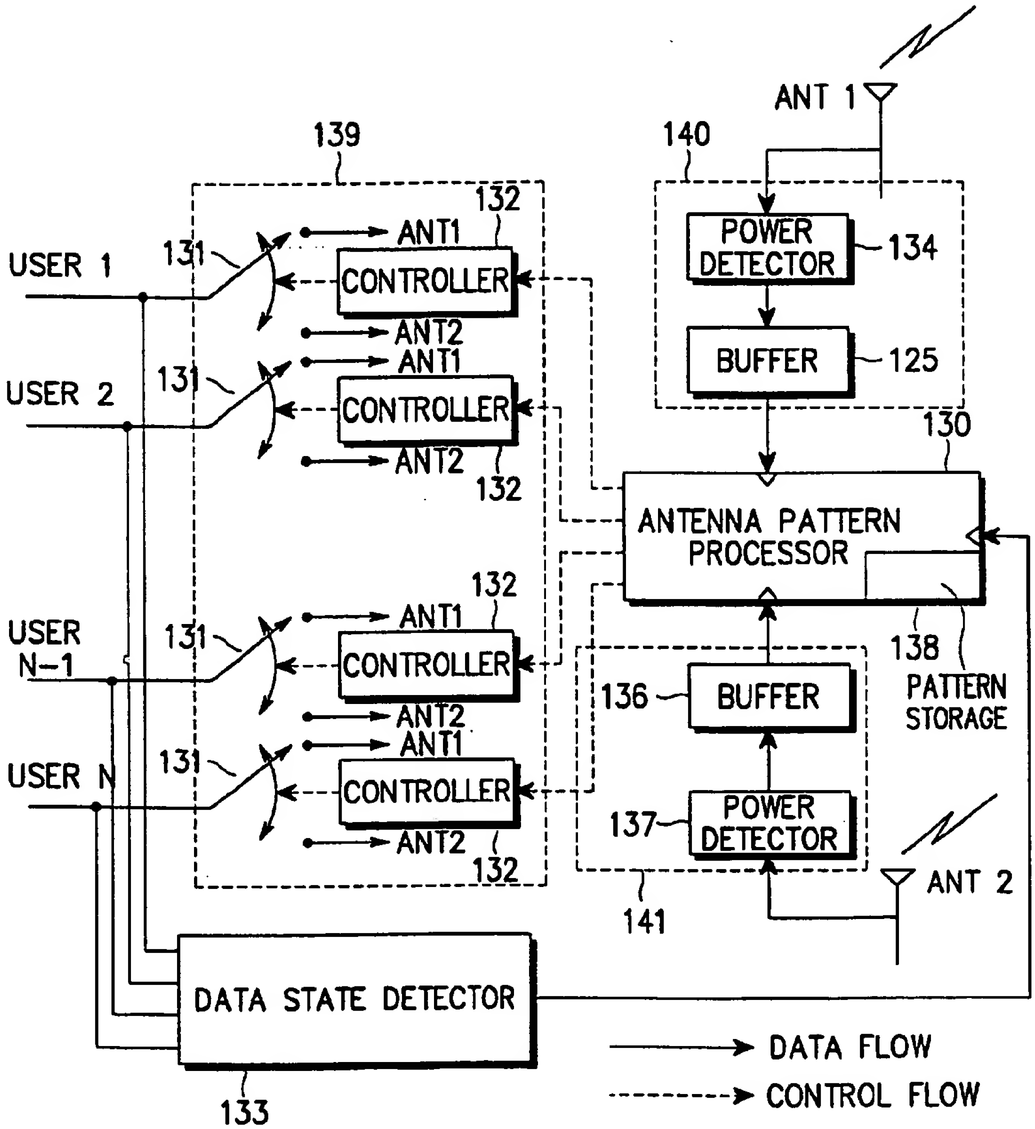

139
140
ANT 1
USER 1
USER 2
USER N-1
USER N
131
132
ANT1
ANT2
CONTROLLER
POWER DETECTOR
134
BUFFER
125
130
ANTENNA PATTERN PROCESSOR
138
PATTERN STORAGE
136
137
141
ANT 2
DATA STATE DETECTOR
133
DATA FLOW
CONTROL FLOW

FIG. 5

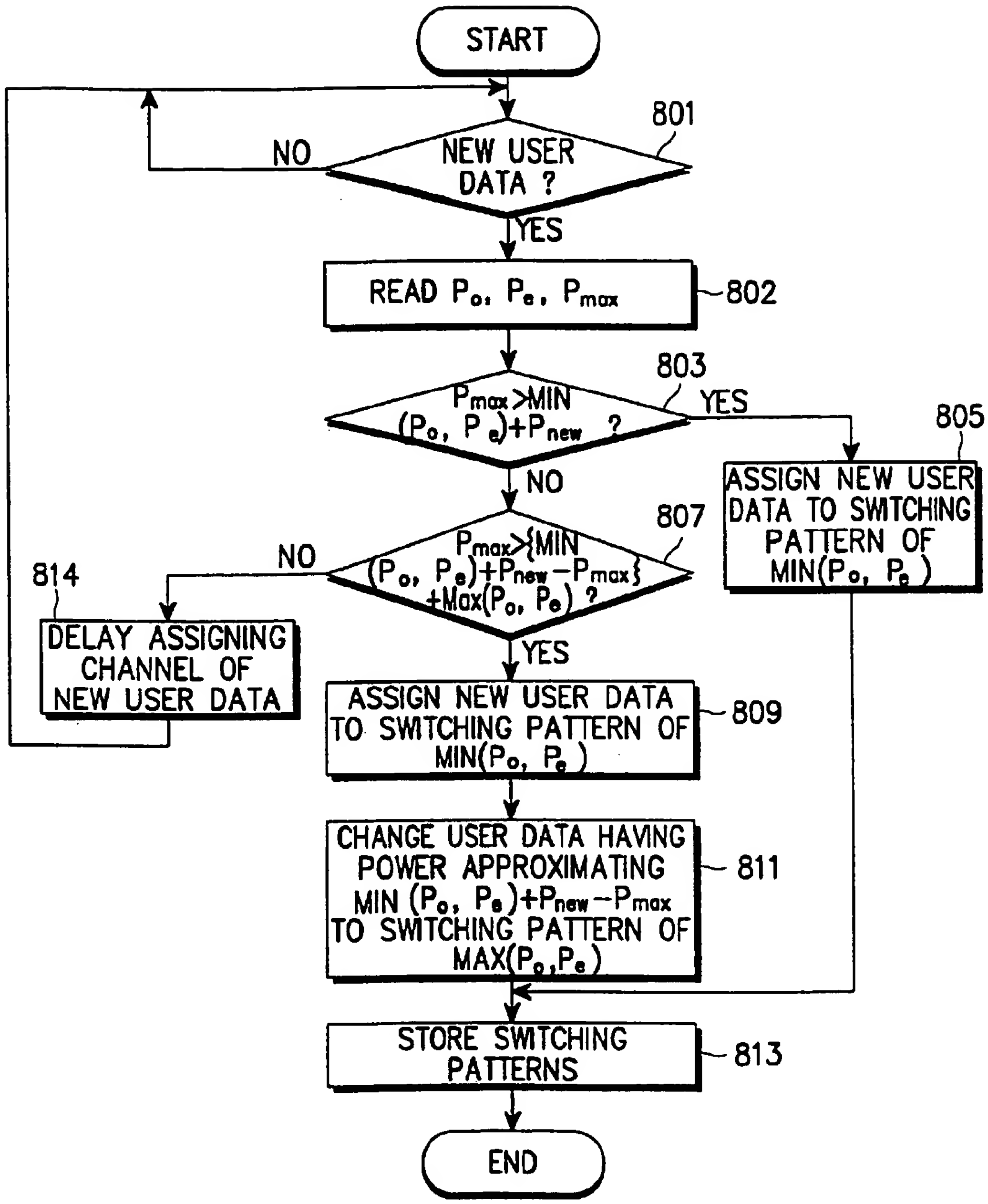

START
NEW USER DATA ?
801
NO
YES
READ Po, Pe, Pmax
802
Pmax >MIN (Po, Pe)+Pnew ?
803
YES
NO
ASSIGN NEW USER DATA TO SWITCHING PATTERN OF MIN(Po, Pe)
805
Pmax>{MIN (Po, Pe)+Pnew −Pmax} +Max(Po, Pe) ?
807
NO
YES
DELAY ASSIGNING CHANNEL OF NEW USER DATA
814
ASSIGN NEW USER DATA TO SWITCHING PATTERN OF MIN(Po, Pe)
809
CHANGE USER DATA HAVING POWER APPROXIMATING MIN (Po, Pe)+Pnew −Pmax TO SWITCHING PATTERN OF MAX(Po,Pe)
811
STORE SWITCHING PATTERNS
813
END

FIG. 6

FIG. 7A

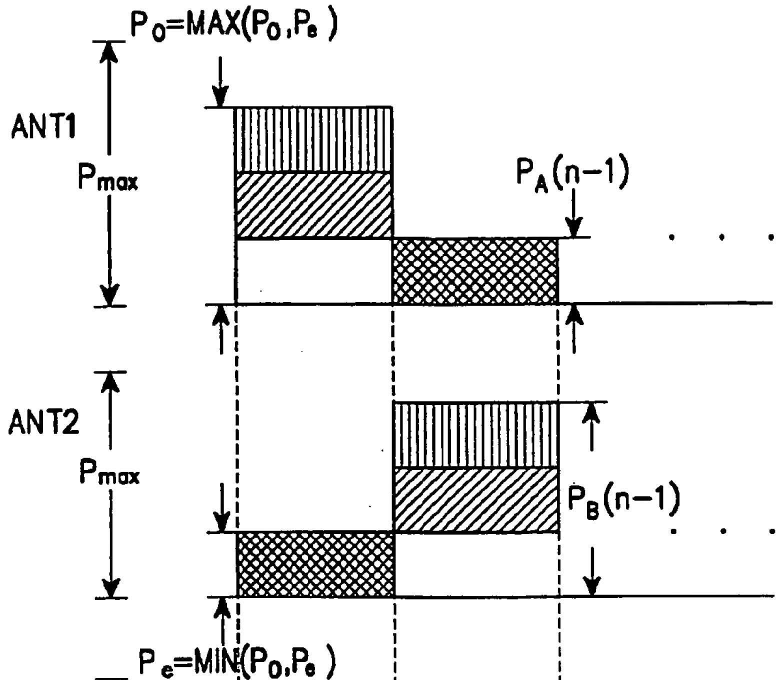

P_0=MAX(P_0,P_e)
ANT1
P_{max}
P_A(n-1)
ANT2
P_{max}
P_B(n-1)
P_e=MIN(P_0,P_e)

FIG. 7B

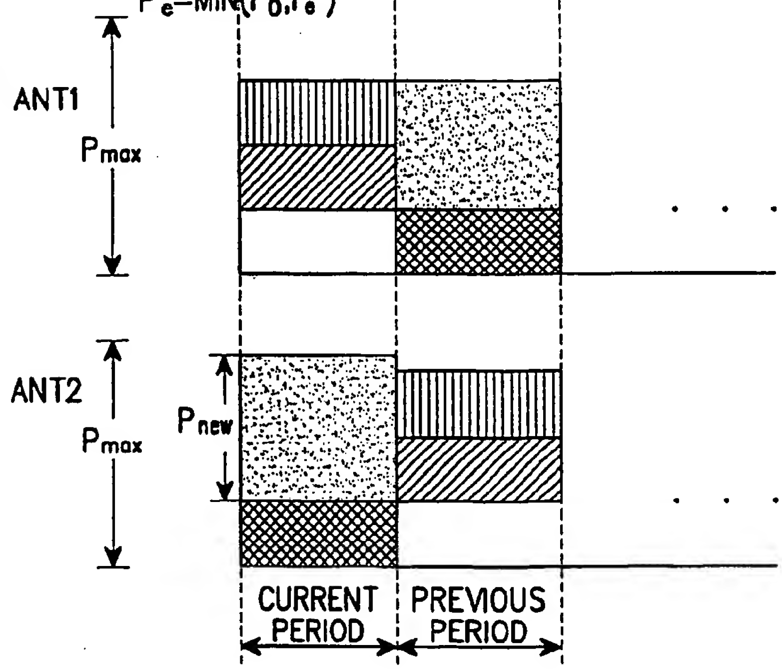
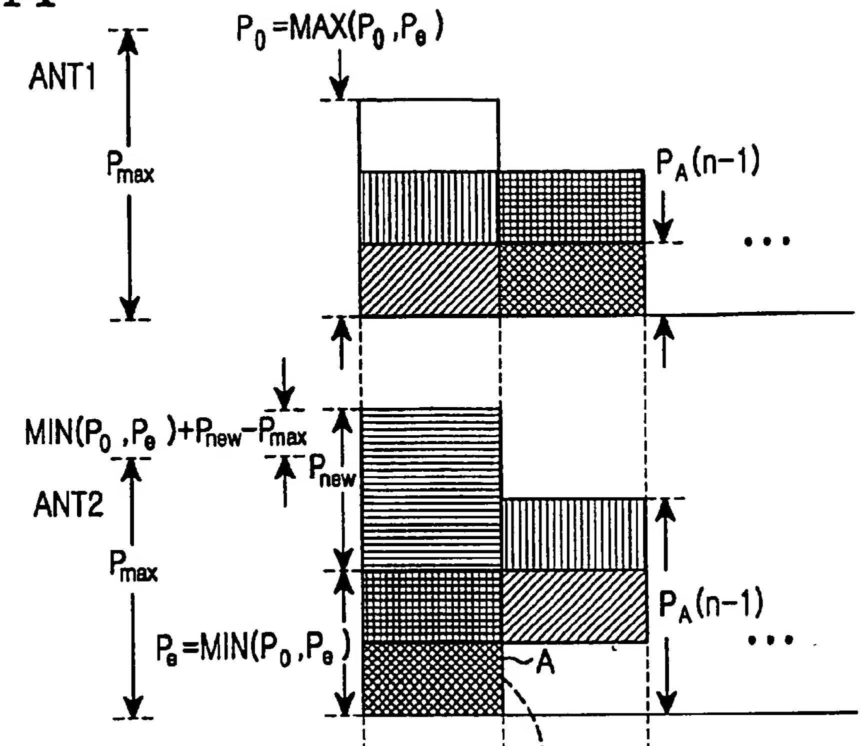
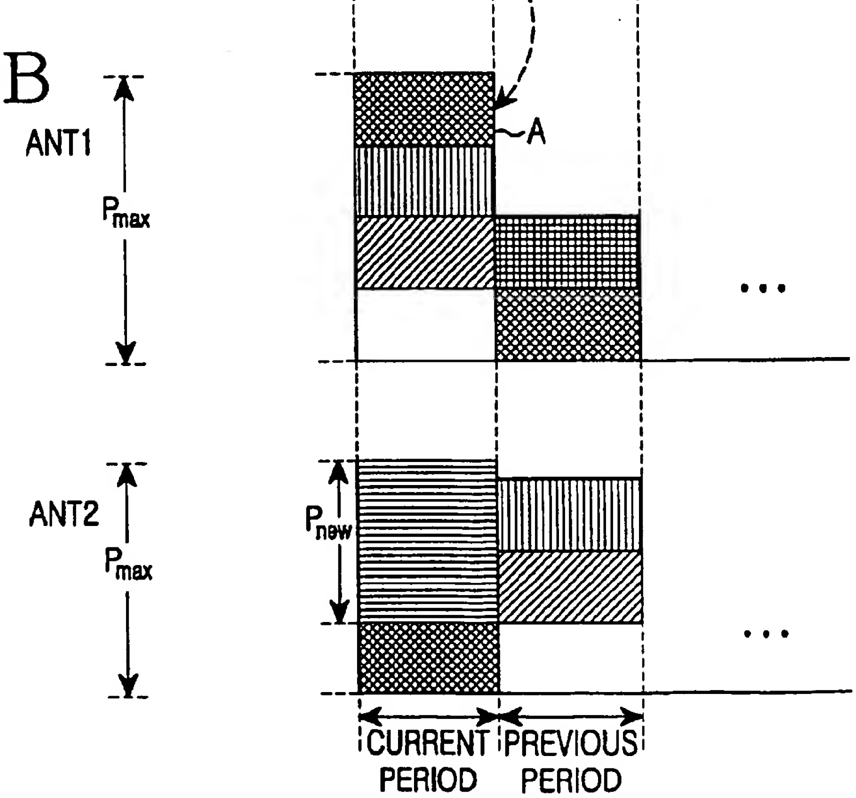

ANT1
P_{max}
ANT2
P_{max}
P_{new}
CURRENT PERIOD
PREVIOUS PERIOD

FIG.8A



P_0=MAX(P_0,P_e)
ANT1
P_{max}
P_A(n-1)
MIN(P_0,P_e)+P_{new}-P_{max}
P_{new}
ANT2
P_{max}
P_A(n-1)
P_e=MIN(P_0,P_e)
A

FIG.8B



ANT1
P_{max}
A
ANT2
P_{max}
P_{new}
CURRENT PERIOD
PREVIOUS PERIOD

TSTD TRANSMITTER FOR LIMITING TRANSMISSION POWER OF ANTENNA AND CONTROLLING METHOD THEREOF FOR BASE STATION IN MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a time-switched transmission diversity (TSTD) transmitter and a controlling method thereof in a code division multiple access (CDMA) mobile communication system, and more particularly, to a TSTD transmitter for limiting a power of a signal transmitted through any antenna to a maximum transmission power of the antenna and a controlling method thereof.

2. Description of the Related Art

In a mobile communication system, received signal levels relating to transmission of a radio frequency signal change rapidly. A rapid change in the receiving signal level is called fading. To reduce fading, a reception diversity scheme is used in which the number or arrangement of antennas in a mobile terminal is changed to improve reception sensitivity over that of a mobile terminal having a single antenna. Although the reception diversity scheme has improved reception performance, it has scarcely been used due of the required increased complexity of the mobile terminal and the resulting increase in cost.

Another option for reducing fading is using a third generation mobile communication system, such as an IMT-200 system, which attains the effect of reception diversity by using transmission diversity. In transmission diversity a plurality of antennas are installed in a base station instead of a mobile terminal. If the mobile station moves slowly (i.e., if the Doppler frequency is low) and if there are a small number of multiple paths (i.e., if there is little delay spread), the transmission diversity can obtain a diversity effect of up to 4–7 dB. Transmission diversity is typically classified into orthogonal transmission diversity (OTD), time-switched transmission diversity (TSTD), and selective transmission diversity (STD).

FIG. 1 illustrates a conventional OTD transmitter. Data is separated equally by a data separator **101** and then transmitted through first and second antennas via multiplexers (MUXs)**102**, serial/parallel (S/P) converters **103**, mixers **104** and **105**, complex PN (Pseudo Noise) spreaders **107**, low-pass filters (LPFs) **109**, mixers **110** and **111**, and adders **112**. An OTD transmitter, as shown in FIG. 1, requires an amplifier with half the power of a conventional power amplifier, since data is equally separated.

FIG. 2 illustrates a conventional TSTD transmitter. A MUX **113** converts logical signals "0" and "1" into actual transmission signals "+1" and "−1". An S/P converter **114** separately outputs even symbols and odd symbols. The even symbols are multiplied by an orthogonal code in a mixer **115** and then provided to a complex PN spreader **117**, and the odd symbols are multiplied by the orthogonal code in a mixer **116** and then provided to the complex PN spreader **117**. The complex PN spreader **117** complex-multiplies the outputs of the mixers **115** and **116** by I-channel and Q-channel data PN_I and PN_Q. A switching circuit **125** switches data which is separately output by the complex PN spreader **117** into data corresponding to the number of antennas to either one of two pairs of corresponding LPFs **119** and **120**. A controller **121** controls the switching circuit **125** to switch user data in the unit of slots as shown in FIG.

3. The output of the LPF **119** is multiplied by a carrier frequency signal in a mixer **122** and then provided to an adder **124**. The output of the LPF **120** is multiplied by a 90° phase-shifted carrier frequency signal in a mixer **123** and then provided to the adder **124**. The adder **124** adds the outputs of the mixers **122** and **123** to each other and transmits the added result via a corresponding antenna.

When data is switched in the unit of slots in the conventional TSTD scheme, a power P_o assigned to the first antenna at a current period and a power P_e assigned to the second antenna at a current period are not equally distributed, as is illustrated in FIGS. 4B and 4C. FIG. 4A illustrates the transmission power for a NON-TSTD mode. The NON-TSTD mode illustrated in FIG. 4A needs one transmission amplifier, whereas the TSTD mode illustrated in FIGS. 4B and 4C requires, in the worst case, as many transmission amplifiers as the number of antennas.

As described above, a TSTD base station requires more transmission amplifiers than a non-TSTD base station and also requires the transmission amplifier to have a higher power than the transmission amplifier used in an OTD base station. This disadvantage regarding the TSTD base station results in increased cost and complexity when compared to non-TSTD base stations or OTD base stations.

In the TSTD mode, the power of a signal transmitted through any antenna may exceed a maximum transmission power of the antenna even if transmission amplifiers are provided with respect to every antenna, in which case, the signal may be lost.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a device and method for limiting the power of a signal transmitted through any antenna to a maximum transmission power of the antenna in a TSTD transmitter.

It is another object of the present invention to provide a device and method for limiting a transmission power of an antenna by changing user data to a switching pattern of another antenna which does not exceed a maximum transmission power whenever the power of a signal transmitted through any antenna exceeds a maximum transmission power of that antenna.

In accordance with one aspect of the present invention, a device for limiting a transmission power of an antenna in a TSTD transmitter of a base station of a mobile communication system is provided, which comprises at least two antennas, a plurality of user channels, and a switching controller connected to the user channels, for switching user data received through the user channels to the antennas. The device includes a data state detector connected to the user channels, for measuring a power of user data on the user channels, a transmission power detector for measuring transmission powers of signals transmitted through the antennas, and an antenna pattern processor for storing a maximum transmission power of the antennas and switching pattern information for previously assigned user data, determining a switching pattern for assigning the new user data to a specific antenna of which transmission power added to a power of the new user data does not exceed the maximum transmission power, and controlling the switching controller and updating the switching pattern information, according to the determined switching pattern.

In accordance with another aspect of the present invention, a method for limiting a transmission power of an antenna in a TSTD transmitter of a base station of a mobile communication system is provided, the system comprising

at least two antennas and a pattern storage for storing a maximum transmission power limit value and switching patterns of a plurality of user data to be transmitted through the antennas. The method comprises the steps of measuring transmission powers assigned to the respective antennas upon receipt of new user data, and determining a switching pattern such that a value obtained by adding one of the transmission powers to a power of the new user data does not exceed the maximum transmission power limit value.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a block diagram illustrating a prior art OTD transmitter;

FIG. 2 is a block diagram illustrating a prior art TSTD transmitter;

FIG. 3 illustrates examples of transmitting user data in a non-TSTD mode and a TSTD mode;

FIGS. 4A, 4B and 4C illustrate transmission powers in a non-TSTD mode and of first and second antennas in a TSTD mode;

FIG. 5 is a block diagram illustrating a TSTD transmitter according to the present invention;

FIG. 6 is a flow chart illustrating a processing procedure for limiting a transmission power of an antenna according to the present invention;

FIG. 7A illustrates one example of transmission powers assigned to antennas;

FIG. 7B illustrates the assignment of new user data power according to the present invention;

FIG. 8A illustrates another example of transmission powers assigned to antennas; and

FIG. 8B illustrates the assignment of new user data and a change of a switching pattern according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described hereinbelow with reference to the accompanying drawings. In the following description, well known constructions or functions are not described in detail so as not to obscure the present invention.

The symbols and definitions used in the present invention are shown below. Assuming that the powers of the first and second antennas preceding a current period by one period are $P_A(n-1)$ and $P_B(n-1)$, respectively, and powers of the first and second antennas at a current period are P_o and P_e, respectively, these powers can be defined as:

$$P_A(n-1)=\sum_{i=0}^{N_A} P_i^A(n-1)+\text{offset} \qquad \text{Equation 1}$$

$$P_B(n-1)=\sum_{i=0}^{N_B} P_i^B(n-1)+\text{offset} \qquad \text{Equation 2}$$

$$P_o=P_B(n-1)-\alpha \qquad \text{Equation 3}$$

$$P_e=P_A(n-1)-\beta \qquad \text{Equation 4}$$

where P_i^A is a power of the i-th user channel in a group transmitted through the first antenna, P_i^B is a power of the i-th user channel in a group transmitted through the second antenna, N_A is the number of users in a group transmitted through the first antenna, N_B is the number of users in a group transmitted through the second antenna, "offset" is a basically transmitted power, α is an extinguished power (due to users who stop calling) in a group transmitted through the first antenna at a current period, and β is an extinguished power in a group transmitted through the second antenna at a current period.

A maximum transmission power of an antenna is defined as P_{max} and a power of a newly assigned user channel as P_{new}.

FIG. 5 illustrates a TSTD transmitter according to the present invention. The TSTD transmitter includes at least two antennas. In FIG. 5, the TSTD transmitter illustrated has two antennas.

Referring to FIG. 5, the TSTD transmitter includes a switching controller **139**, a first transmission power detector **140**, a second transmission power detector **141**, an antenna pattern processor **130**, and a data state detector **133**. The switching controller **139** has a plurality of switching circuits **131** and controllers **132**. The first transmission power detector **140** has a power detector **134** and a buffer **125**. The second transmission power detector **141** has a power detector **137** and a buffer **136**. The switching circuits **131** are coupled to respective user channels and switch user data input through corresponding channels to first and second antennas ANT1 and ANT2 as instructed by each respective controller **132**. The controllers **132** are coupled to the switching circuits **131** and determine which of the two antennas is to be switched to the switching circuits **131** first as instructed by the antenna pattern processor **130**.

The data state detector **133** is connected to the user channels. If new user data is received through the user channels, the data state detector **133** detects a power of the received data and provides the detected result to the antenna pattern processor **130**. The data state detector **133** may also detect a data rate and quality of service (QoS). The first transmission power detector **140** is coupled to the first antenna ANT1 and detects the power of a signal transmitted through the first antenna ANT1. The detected transmission power is typically updated within the unit of a predetermined time interval, i.e., one period. The second transmission power detector **141** coupled to the second antenna ANT2 has the same configuration as the first transmission power detector **140**. The power detector **134** of the first transmission power detector **140** measures the power of a transmission signal of the preceding stage of a transmission power amplifier (not shown) for amplifying the power of a signal to be transmitted through the first antenna ANT1; the power detector **137** of the second transmission power detector **141** measures the power of a transmission signal of the preceding stage of a transmission power amplifier (not shown) for amplifying the power of a signal to be transmitted through the second antenna ANT2.

The power value measured by the power detector **134** is stored in the buffer **135**, and the power value measured by the power detector **137** is stored in the buffer **136**. These buffers **135** and **136** store the measured power values during one period. It is assumed in the following description that the transmission power assigned to each antenna is the power of the preceding stage of each transmission power amplifier. The antenna pattern processor **130** includes a pattern storage **138** for storing a maximum transmission power P_{max} value of the antennas and switching pattern

information for assigned channels. The antenna pattern processor **130** determines a switching pattern of each user by analyzing information output from the data state detector **133** and power information stored in the buffers **135** and **136**. The antenna pattern processor **130** also controls the controllers **132** and updates the pattern information of the pattern storage **138**, according to the determined switching pattern. Upon receipt of information such as the data rate or QoS from the data state detector **133**, the antenna pattern processor **130** may determine the switching pattern with priority according to the data rate or QoS.

FIG. **6** is a flow chart showing a processing procedure for limiting a transmission power of an antenna according to the present invention. The process illustrated in FIG. **6** is executed by the antenna pattern processor **130** shown in FIG. **5**.

Referring to FIG. **6**, the antenna pattern processor **130** checks through the data state detector **133** to determine whether new user data is generated from any user channel at step **801**. If the new user data is generated, the antenna pattern processor **130** receives a power P_{new} of the new user data, a data rate and QoS from the data state detector **133**, and power information regarding previously generated user data along with a switching result of each controller **132**. At step **802**, the antenna pattern processor **130** reads powers P_o and P_e assigned to the first and second antennas ANT1 and ANT2 from the buffers **135** and **136**, respectively, and reads the maximum transmission power P_{max} from the pattern storage **138**. The antenna pattern processor **130** checks whether the following equation is satisfied at step **803**.

$$P_{max} > \mathrm{MIN}(P_o, P_e) + P_{new} \qquad \text{Equation 5}$$

where "MIN(P_o, P_e)" is the lower power value of P_o or P_e. If the above Equation 5 is satisfied, the new user data is assigned to a switching pattern of MIN(P_o, P_e), and the assigned result is transmitted to a corresponding mobile station, at step **805**.

If Equation 5 is not satisfied, the antenna pattern processor **130** searches for, from MIN(Po, Pe), user data which has a power approximating $\mathrm{MIN}(P_o, P_e)+P_{new}-P_{max}$ at step **807**. Here, a value obtained by adding the power of the searched user data to MAX(P_o, P_e) should not exceed the maximum transmission power P_{max}. This can be expressed by the following equation:

$$P_{max} > \mathrm{MIN}(P_o, P_e)+P_{new}-P_{max}+\mathrm{MAX}(P_o, P_e)[\ \ldots\ (6)] \qquad \text{Equation 6}$$

If no user data satisfies Equation 6, the antenna pattern processor **130** delays assigning a channel of the new user data at step **814** and then returns to step **801**. If there is user data satisfying Equation 6, the power P_{new} of the new user data is assigned to the switching pattern of MIN(P_o, P_e) at step **809**. At step **811**, the searched user data having a transmission power approximating $\mathrm{MIN}(P_o, P_e)+P_{new}-P_{max}$ is changed to a switching pattern of MAX(P_o, P_e). Namely, the searched user data which has been assigned to the switching pattern of the second antenna is changed to the switching pattern of MAX(P_o, P_e).

One example of steps **803** and **805** is illustrated in FIGS. 7A and 7B. FIG. 7A shows the case that even if the power P_{new} of the new user data is assigned to MIN(P_o, P_e), the entire power does not exceed the maximum transmission power P_{max}. In FIG. 7A, since the power P_o assigned to the first antenna ANT1 at a current period is higher than the power P_e assigned to the second antenna ANT2 at a current period, P_o=MAX(P_o, P_e) and P_e=MIN(P_o, P_e). More particularly, since the second antenna ANT2 has a lower power at a current period, the antenna pattern processor **130** assigns a switching pattern the user pattern having the power P_{new} to the second antenna ANT2, as shown in FIG. 7B, by causing the corresponding controller **132** to switch the new user data to the second antenna ANT2. If $\mathrm{MIN}(P_o, P_e)+P_{new}$ is not greater than P_{max}, step **805** is implemented.

A detailed description of steps **807** to **813** is provided herein by referring to FIGS. **8A** and **8B**. The antenna pattern processor **130** assigns the power P_{new} at a current period to the second antenna ANT2 having a lower transmission power than the first antenna ANT1 as shown in FIG. **8A**. However, since $\mathrm{MIN}(P_o, P_e)+P_{new}$ is greater than P_{max}, the antenna pattern processor **130** searches for user data having a transmission power which is greater than and approximates $\mathrm{MIN}(P_o, P_e)+P_{new}-P_{max}$. A user data having a low QoS and less pattern change is selected. Assuming that a power of such user data is "A", the antenna pattern processor **130** checks whether a value obtained by adding a power of the user data "A" to MAX(P_o, P_e) (=P_o) is less than P_{max}. If so, the power P_{new} of the new user data is assigned to the transmission power P_e of the second antenna ANT2 at step **809**, and the power of the user data "A" is assigned to the transmission power P_o of the first antenna at step **811** as indicated in FIG. 8B. Referring back to FIG. **6**, the antenna pattern processor **130** stores the pattern to which the new user data is assigned and the changed pattern in the pattern storage **138** at step **813**.

In accordance with the present invention, the TSTD transmitter uses transmission amplifiers dissipating a low power by limiting a power of a signal transmitted through an antenna to a maximum transmission power and thus reduces complexity and cost in a base station.

While the invention has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A device for limiting a transmission power of an antenna in a time-switched transmission diversity (TSTD) transmitter of a base station of a mobile communication system including at least two antennas, a plurality of user channels, and a switching controller connected to the user channels, for switching user data received through the user channels to the antennas, said device comprising:

- a data state detector connected to the user channels, for measuring a power of new user data on the user channels;
- a transmission power detector for measuring transmission powers of signals transmitted through the antennas; and
- an antenna pattern processor for storing a maximum transmission power of the antennas and switching pattern information for previously assigned user data, determining a switching pattern for assigning the new user data to a specific antenna of which transmission power added to a power of the new user data does not exceed the maximum transmission power, and controlling the switching controller and updating the switching pattern information, according to the determined switching pattern.

2. The device as recited in claim **1**, wherein the transmission power detector comprises:

- a power detector for measuring transmission powers of the antennas; and
- a buffer for storing the measured transmission power values during a predetermined interval.

3. The device as recited in claim 2, wherein the transmission power detector includes a respective power detector and buffer corresponding to each antenna.

4. The device as recited in claim 1, wherein the antenna pattern processor includes a pattern storage for storing the maximum transmission power of each antenna and storing the switching pattern information to control the switching controller to switch the user data to the antennas.

5. The device as recited in claim 1, wherein the antenna pattern processor determines the switching pattern by assigning the power of the new user data to an antenna having the least transmission power, when all values obtained by adding the power of the new user data to the respective transmission powers of the antennas do not exceed the maximum transmission power.

6. A method for limiting a transmission power of an antenna in a time-switched transmission diversity (TSTD) transmitter of a base station of a mobile communication system, the system comprising at least two antennas and a pattern storage for storing a maximum transmission power limit value and switching patterns of a plurality of user data to be transmitted through the antennas, said method comprising the steps of:

measuring transmission powers assigned to the respective antennas upon receipt of new user data; and

determining a switching pattern such that a value obtained by adding one of the transmission powers to a power of the new user data does not exceed the maximum transmission power limit value.

7. The method as recited in claim 6, wherein the step of determining a switching pattern comprises the steps of:

calculating a first power value, the first power value being a user data assigned minimum transmission power, by adding the power of the new user data to a minimum transmission power among the transmission powers;

checking whether the first power value is less than the maximum transmission power limit value;

searching for pattern change data having a power approximating a second power value which is obtained by subtracting a maximum transmission power limit value from the first power value, when the first power value is greater than the maximum transmission power limit value;

checking whether a third power value obtained by adding a power of the pattern change data to the maximum transmission power among the transmission powers is less than the maximum transmission power limit value; and

assigning the new user data to the antenna having the minimum transmission power and changing a switching pattern of the pattern change data when the third power value is less than the maximum transmission power limit value.

8. The method as recited in claim 7, further comprising the step of assigning the power of the new user data to the minimum transmission power when the first power value is less than the maximum transmission power limit value.

9. The method as recited in claim 7, further comprising the step of delaying assigning a channel of the new user data when the third power value is greater than the maximum transmission power limit value.

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